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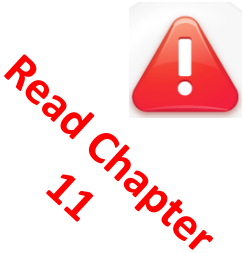


Data Management

Dr. Abdelkarim Erradi

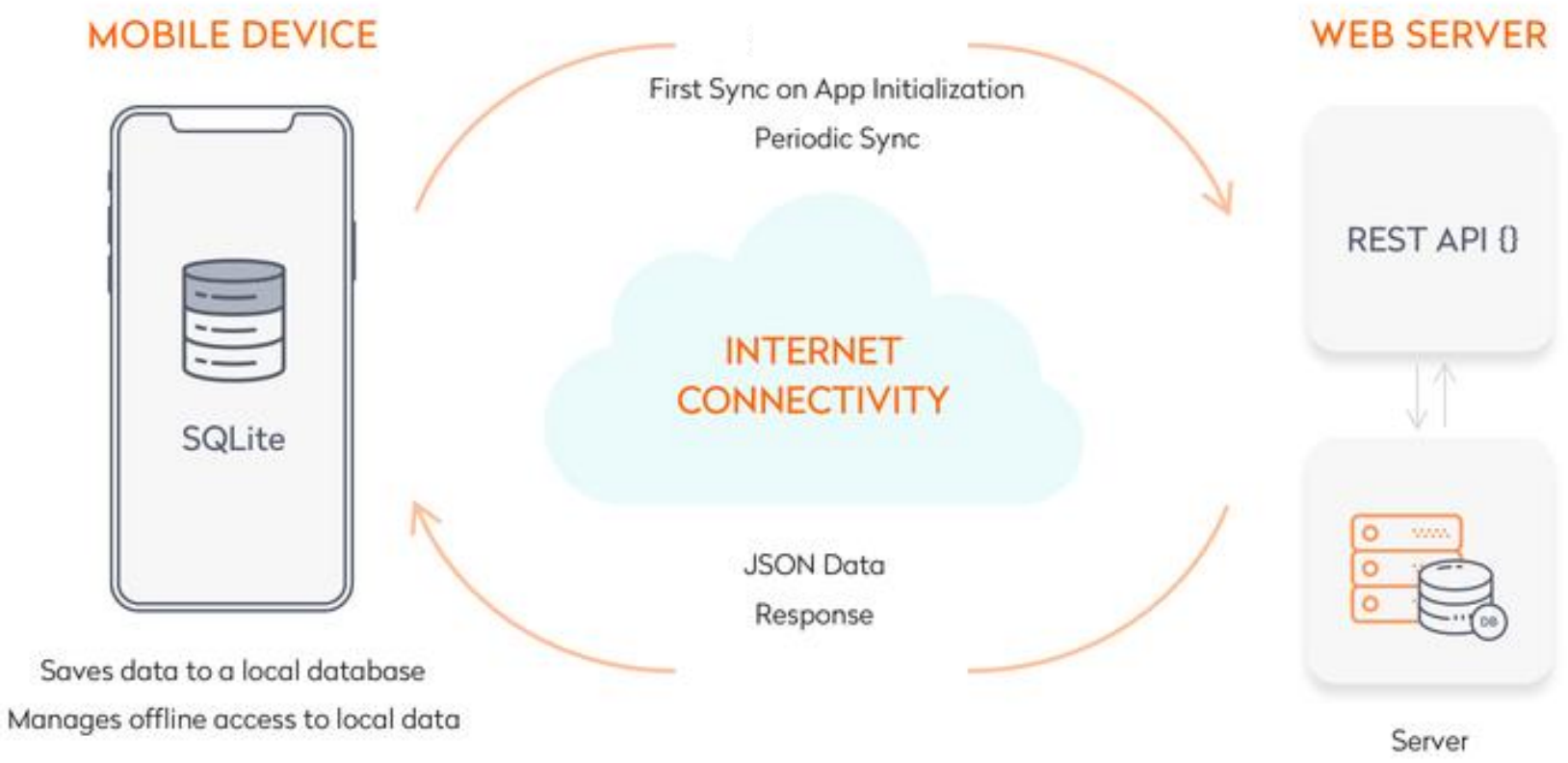
CSE@QU

Outline

1. Data persistence options on Android
2. Room programming model
3. Type Converters, Embedded object, Foreign keys & Map Queries
4. Observable Queries using LiveData

Data persistence options on Android

Offline app with Sync



- **Cache** relevant pieces of data on the device. App continues to work offline when a network connection is not available.
- When the network connection is back, the app's repository **syncs** the data with the server.

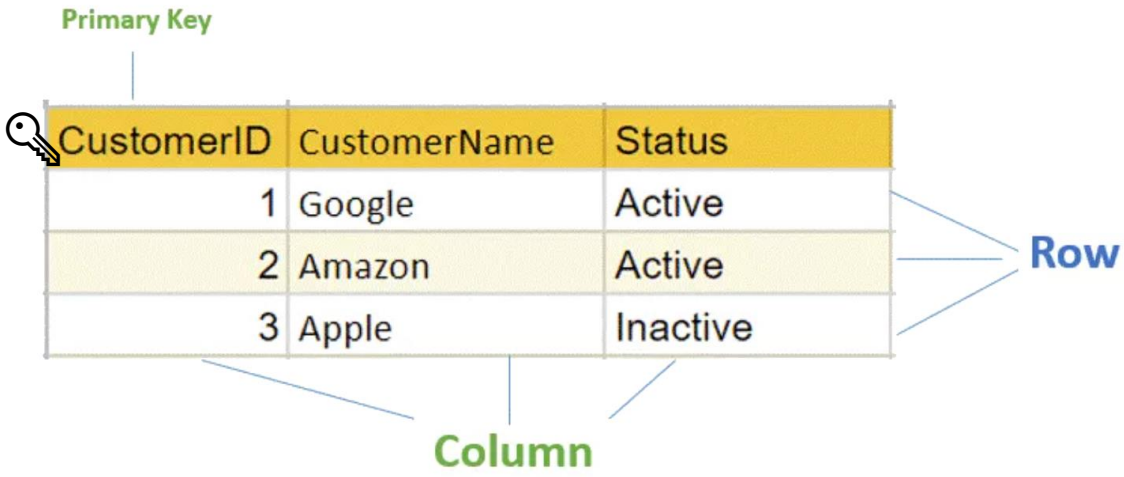
Data Storage Options on Android

- **Preferences DataStore**
  - Lightweight mechanism to store and retrieve key-value pairs
  - Typically used to store application settings (e.g., app theme, language), store user details after login
- **Files**
  - Store unstructured data such as text, photos or videos, on the device (Current application folder only) or removable storage
- 

database
  - Store structured data (e.g., posts, events) in tables
- **Cloud Data Stores**
  - e.g., 

Relational Database

- Database allows **persisting structured data**
- A **relational** database organizes data into **tables**
  - A table has rows and columns
  - Tables can have relationships between them
- Tables could be queries and altered using SQL



SQL Statements

- Structured Query Language (**SQL**)
  - Language used to define, query and alter database tables
  - SQL is a language for interacting with a relational database
- **C**reating data:

```
INSERT into Person (firstName, lastName)
  VALUES ("Ahmed", "Sayed")
```

- **R**eading data:

```
SELECT * FROM Person WHERE lastName = "Sayed"
```

- **U**pdating data:

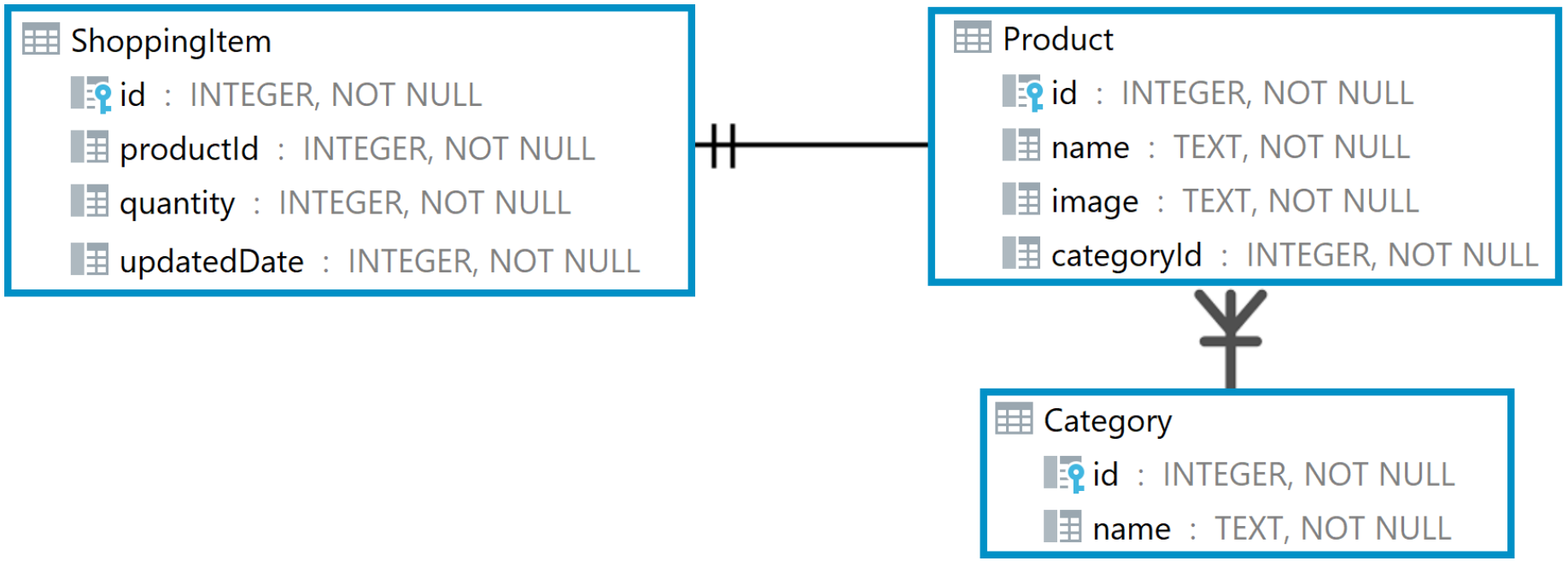
```
UPDATE Person SET firstName = "Ali" where
     lastName = "Sayed"
```

- **D**eleting data:

```
DELETE from Person where lastName = "Sayed"
```

Database Schema of Shopping List App

- The Entity Relationship (ER) diagram of the Shopping List App database
  - A ShoppingItem has an associated Product
  - Product has a Category
  - Category has many products



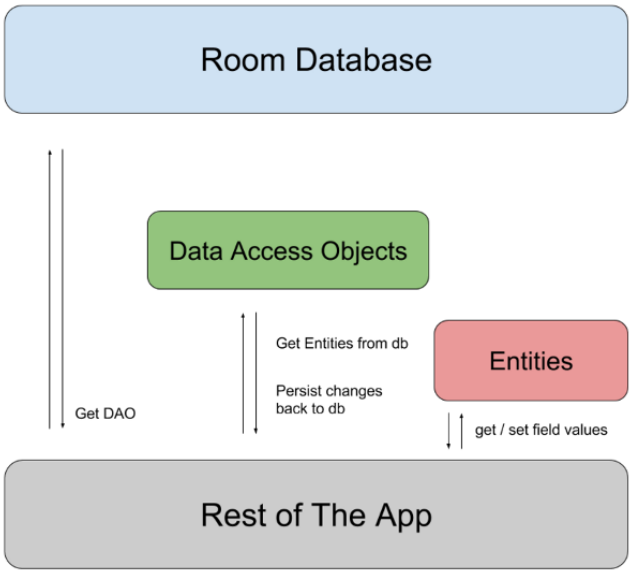
Querying Multiple Tables with Joins

- Combine rows from multiple tables by matching common columns
  - For example, return rows that combine data from the **Product** and **Category** tables by matching the **Product.categoryId** foreign key to the **Category.id** primary key

```
select p.id, p.name, p.image, c.name category
    from Product p join Category c on p.categoryId = c.id
    where p.categoryId = '1'
```

id	name	image	category
1	Grapes		Fruits
2	Melon		Fruits
3	Watermelon		Fruits
4	Banana		Fruits
5	Pineapple		Fruits
6	Mango		Fruits
7	Red Apple		Fruits
8	Green Apple		Fruits
9	Pear		Fruits
10	Peach		Fruits

Room programming model



Back

Room Library

- The **Room** persistence library provides an abstraction layer over SQLite to ease data management
  - Define the database, its tables and data operations using **annotations**
    - Room automatically translates these annotations into SQLite instructions/queries to be executed by the DB engine
- **Dependencies:**

```
plugins {
    ...
    id 'kotlin-kapt'
}
```

```
def room_version = "2.4.0-beta01"
implementation "androidx.room:room-runtime:$room_version"
kapt "androidx.room:room-compiler:$room_version"
// Kotlin Extensions and Coroutines support for Room
implementation "androidx.room:room-ktx:$room_version"
```

Room architecture diagram

Working with Room

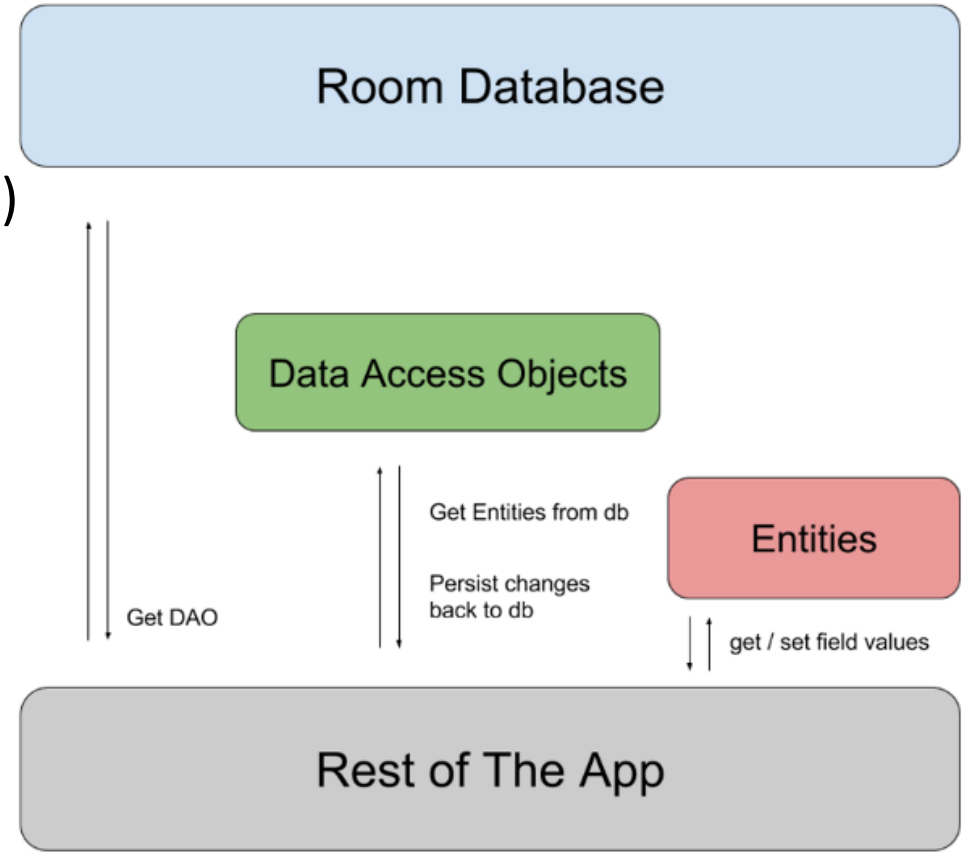
1. Model DB Tables as regular **Entity Classes**
2. Create Data Access Objects (DAOs)

   - **DAO interface** methods are annotated with queries for Select, Insert, Update and Delete

   - DOA implementation is auto-generated by the complier

   - DOA is used to interact with the database
3. **RoomDatabase** → holds a connection to the SQLite DB and all the operations are executed through it

3 major components in Room



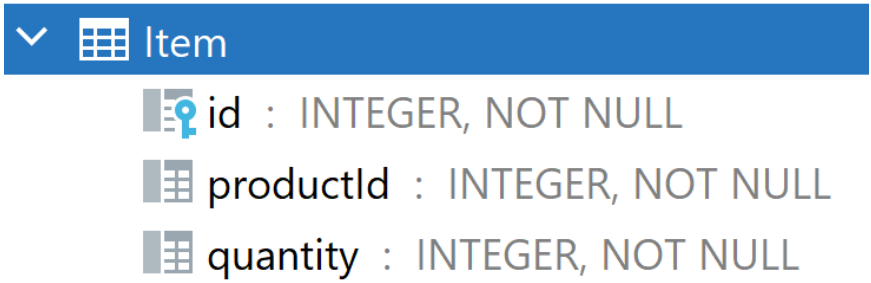
Room main components

- **Entity** → each entity class is mapped to a DB table
  - Kotlin class annotated with **@Entity** to map it to a DB table
  - Must specify one of the entity properties as a **primary key**
  - Table name = Entity name & Column names = Property names (but can be changed by annotations)
- Data Access Object (**DAO**) → has methods to read/write entities
  - Contains CRUD methods defining operations to be done on data
  - Interface or abstract class marked as **@Dao**
  - One or many DAOs per database
- **Database** → where data is persisted
  - abstract class that extends **RoomDatabase** and annotated with @Database

Entity

- Entity represents a database table, and each entity instance corresponds to a row in that table
  - Class properties are mapped to table columns
  - Each entity object has a Primary Key that **uniquely identifies** the entity object in memory and in the DB
  - The primary key values can be assigned by the database by specifying **`autoGenerate = true`**

```
@Entity
data class Item(
    @PrimaryKey(autoGenerate = true)
    val id: Long = 0
    val productId: Long,
    var quantity: Int)
```



Customizing Entity Annotations

- By default, the name of the entity class is the same as the associated table and the name of table columns are the same as the class properties
  - In most cases, the defaults are sufficient but can be customized
  - Use @Entity (tableName = "…") to set the name of the table
  - The columns can be customized using **@ColumnInfo**(name = "column_name") annotation
- If an entity has properties that you don't want to persist, you can annotate them using **@Ignore**

DAO @Query

- **@Query** used to annotate query methods
- Room ensures **compile time verification** of SQL queries

```
@Dao
interface UserDao {
    @Query("select * from User limit 1")
    suspend fun getFirstUser(): User
    @Query("select * from User")
    suspend fun getAll(): List<User>
    @Query("select firstName from User")
    suspend fun getFirstNames(): List<String>
    @Query("select * from User where firstName = :fn")
    suspend fun getUsers(fn: String): List<User>
    @Query("delete from User where lastName = :ln")
    suspend fun deleteUsers(ln: String): Int
}
```

DAO @Insert, @Update, @Delete

- Used to annotate insert, update and delete methods
- Suspend ensure that DB operations are not done on the main UI thread

```
@Dao
interface UserDao {
    @Insert
    suspend fun insert(user: User): Long
    @Insert
    suspend fun insertList(users: List<User>): List<Long>

    @Delete
    suspend fun delete(user: User)
    @Delete
    suspend fun deleteList(users: List<User>)

    @Update
    suspend fun update(user: User)
    @Update
    suspend fun updateList(users: List<User>)
}
```

Room database class

- Abstract class that extends **RoomDatabase** and Annotated with **@Database**
- Provides a **singleton** dbInstance object created using **Room.databaseBuilder()** to create (if does not exit) and connect to the database
- Serves as the **main access point** to get DAOs to interact with DB

```
@Database(entities = [Item::class], version = 1)
abstract class ShoppingDB : RoomDatabase() {
    companion object { // Create a singleton dbInstance
        private var dbInstance: ShoppingDB? = null
        fun getInstance(context: Context): ShoppingDB {
            if (dbInstance == null) {
                dbInstance = Room.databaseBuilder(
                    context,
                    ShoppingDB::class.java, "shopping.db"
                ).fallbackToDestructiveMigration().build()
            }
            return dbInstance as ShoppingDB
        }
    }
}
```

Type Converters, Embedded object, Foreign keys & Map Queries

TypeConverter

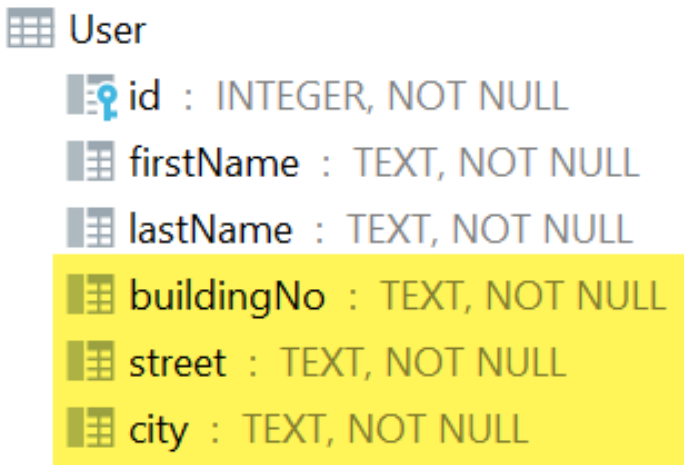
- SQLite only support basic data types, no support for data types such as Date, enum, BigDecimal etc. Need to add a **TypeConverter** for such data types
- Convert an entity property datatype to a type that can be written to the associated table column and vice versa

```
class DateConverter {
    // Convert from Date to a value that can be stored in SQLite Database
    @TypeConverter
    fun toLong(date: Date) : Long = date.time

    // Convert from date Long value read from SQLite DB to a Date value
    // that can be assigned to an entity property
    @TypeConverter
    fun toDate(dateLong: Long) : Date = Date(dateLong)
}

@TypeConverters(DateConverter::class)
abstract class ShoppingDB : RoomDatabase() { … }
```

Nested @Embedded object

- Nested object annotated with @Embedded -> Room **flattens out** the embedded object and maps its properties to columns in the DB table
  - User table will have a buildingNo, street and city columns

```
data class Address(val buildingNo: String,
                   val street: String,
                   val city: String)
@Entity
data class User (
    @PrimaryKey(autoGenerate = true)
    var id: Long,
    val firstName: String,
    val lastName: String,
    @Embedded val address: Address
)
```



Enforce integrity checks with foreign keys

- Foreign key allows **integrity checks** (e.g., can insert pet only for a valid owner) & **cascading** deletes
  - onDelete = **ForeignKey.CASCADE** when owner is deleted then auto-delete associated pets

```
@Entity(foreignKeys = [
        ForeignKey(entity = Owner::class,
                parentColumns = ["id"],
                childColumns = ["ownerId"],
                onDelete = ForeignKey.CASCADE)
        ],
    // Create an index on the ownerId column to speed-up query execution
    indices = [Index(value = ["ownerId"])])
data class Pet(@PrimaryKey val id: Long,
               val name: String, val ownerId: Long)
@Entity
data class Owner(@PrimaryKey val id: Long, val name: String)
```

Queries that Return a Map

- For each category return a list of associated products

```
@Query("""
   Select c.*, p.*
   From Category c join Product p on c.id = p.categoryId
   """)
suspend fun getCategoriesAndProducts(): Map<Category, List<Product>>
```

- For each category return the count of associated products
- **@MapInfo** will be required when the key or value column of the map are from a single column.

```
@MapInfo(keyColumn = "categoryName", valueColumn = "productCount")
@Query("""
   Select c.name categoryName, count(p.id) as productCount
   From Category c join Product p on c.id = p.categoryId
   Group by c.id
   """)
suspend fun getCategoriesAndProductCounts(): Map<String, Integer>
```

Observable Queries using LiveData

Observable Queries

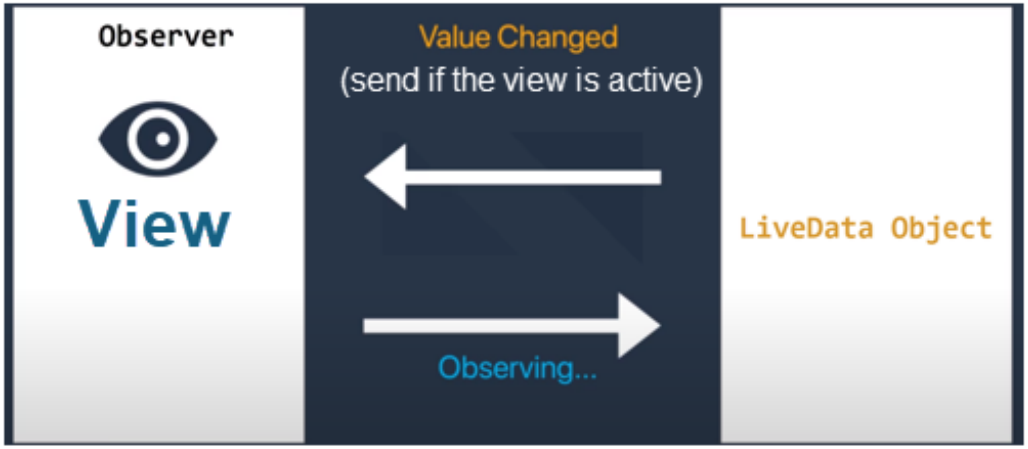
- Observable queries allow automatic notifications when data changes
  - Notifies the app with of any data updates
- We can accomplish this using **LiveData**, a lifecycle-aware **observable** value holder
  - We simply **wrap** the return type of our DAO methods with LiveData
  - **active** observers (i.e., UI) get notified when data change

```
// App will be notified of any changes of the Item table data
// Whenever Room detects Item table data change our LiveData
observer will be called with the new list of items
// No need for suspend function as LiveData is already asynchronous
 @Query("Select * from Item")
fun getAll() : LiveData<List<Item>>
```

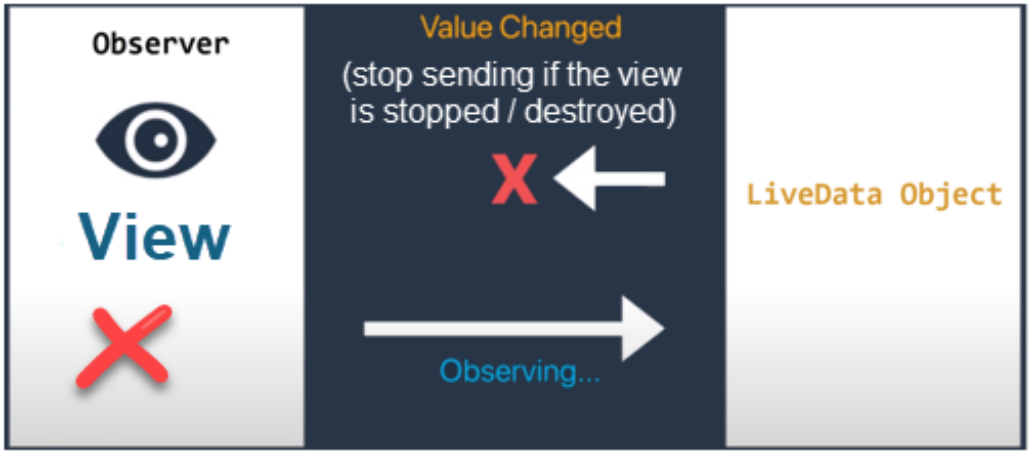
LiveData is lifecycle-aware

LiveData is aware of the Lifecycle of its Observer

- Notifies data changes to only **active** observers (Stopped/Destroyed View will NOT receive updates)

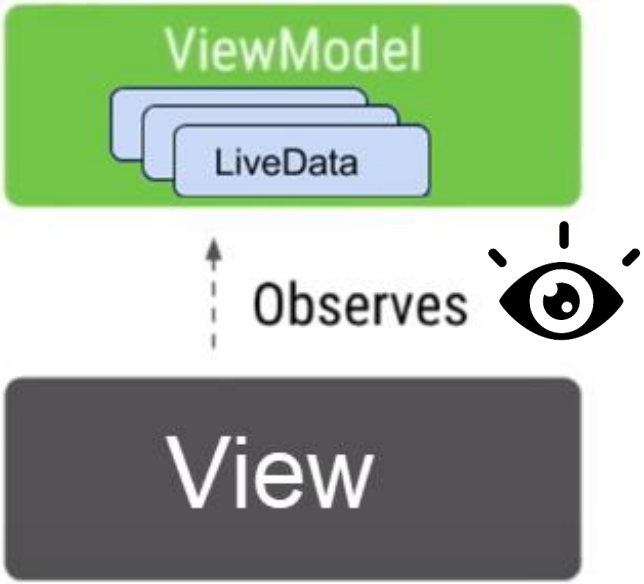


- It automatically removes the subscription when the observer is destroyed so it will not get any updates



LiveData in Code

LiveData **warps around** an object and allows the view to **observe** it



- ViewModel expose LiveData objects that the View can observe

```
//shoppingItemDao
@Query("select count(*) from ShoppingItem")
fun getCount() : LiveData<Long>

object ShoppingRepository {
      fun getCount() = shoppingItemDao.getCount()
}
```

```
class ShoppingViewModel : ViewModel() {
    val shoppingItemsCount = ShoppingRepository.getCount()
}
```

- View **observes** LiveData changes

```
@Composable
fun ShoppingScreen() {
    val viewModel = viewModel<ShoppingViewModel>()
    val itemsCount = viewModel.shoppingItemsCount
                              .observeAsState()
// Recomposes whenever itemsCount changes
Text(
  text = "Items count: ${itemsCount.value}")
}  ... }
```

LiveData.observeAsState()

- LiveData.`observeAsState()` registers as a **listener** and represent the values as a State
  - Whenever a new value is emitted, Jetpack Compose recomposes those parts of the UI where that state.value is used
  - Required dependency in `build.gradle`:

```
implementation "androidx.compose.runtime:runtime-livedata:$compose_version"
```

Summary

Major Components

- **@Entity** - Defines table structure
- **@Dao** - An interface with functions to read/write from the database
- **@Database** - Serves as the **main access point** to get DAOs to interact with DB

Resources

- Save data in a local database using Room
  - https://developer.android.com/training/data-storage/room
- Room pro tips
  - https://medium.com/androiddevelopers/7-pro-tips-for-room-fbadea4bfbd1
- Room codelab
  - https://codelabs.developers.google.com/codelabs/android-room-with-a-view-kotlin/
  - https://developer.android.com/codelabs/kotlin-android-training-room-database
  - https://codelabs.developers.google.com/codelabs/android-preferences-datastore